

southern spot was the brighter of the two, and "appeared then to be composed of a multitude of bright peaks, forming on its northern border a row of brilliant, star-like dots of light." The white spots disappeared after the inferior conjunction, which occurred on February 21.

At the sitting of the Academy of Sciences of Paris on March 24, M. Trouvelot mentioned that on two hundred and forty-two occasions since February 1878 he had observed one or other of the luminous spots, and occasionally both, and had made upwards of one hundred and twenty drawings. Since April 5 in the present year he had not lost sight of the northern spot, which alone was visible at that date. He did not find the spots affected by the diurnal rotation of the planet, and hence infers that the axis passes either through or very close to their centre. In this view it will be interesting to compare the position of the axis of the spots determined by his observations with the results obtained by De Vico and others. An attempt in this direction, founded upon some of the more satisfactory drawings, did not promise a near agreement. M. Trouvelot adds that the spots appear almost permanent, and thinks they are the summits of high mountains projecting beyond the cloudy envelope, generally opaque, which covers the planet.

The observations in 1877-78 were made at Cambridge, U.S., those of the present year at the Observatory of Meudon. De Vico's investigation on the position of the axis of Venus appeared in the *Memoirs* of the Observatory of the Collegio Romano for 1840-1841: it can hardly be said that his results, founded upon data necessarily vague, have inspired much confidence amongst astronomers. He made the inclination of the equator of Venus to the ecliptic  $53^{\circ} 11'$ , and the longitude of the ascending node  $57^{\circ} 19'$  for 1841; the rotation of Venus in sidereal time, 23h. 21m. 21.93s.: these are the figures quoted in Secchi's "Life of De Vico."

THE GREAT COMET OF 1882.—Prof. Howe notifies that he has undertaken a definite determination of the orbit of this comet, which will doubtless be a work of some labour. Thus far calculation appears to indicate that the comet was moving in an ellipse, with a period not differing much from eight centuries: Kreutz gave 843, Fabritius 823, Frisby 794, and Morrison 712 years; the orbit of Fabritius depends upon the widest extent of observation. Between the earliest and latest accurate positions the comet described an orbital arc of  $340^{\circ}$ : a similar arc was traversed by the comet of 1680 between its discovery by Kirch on the morning of November 14 and the last observation by Sir Isaac Newton on March 19 following.

Those who may have unpublished observations of position of the great comet of 1882 will do well to communicate them to Prof. Howe forthwith.

BORSSEN'S COMET OF SHORT PERIOD.—We have not yet met with any intimation that an ephemeris of this comet for the approaching reappearance is being prepared: that for the last return in 1879 was furnished by Prof. L. R. Schulze of Dobeln; the time of perihelion passage was about eleven hours later than his calculation gave it. Disregarding perturbation, the comet would be again due at perihelion in the middle of September next, in which case it would be observable in the two hours before sunrise, in August and September, under somewhat similar conditions to those in 1873. Supposing the perihelion passage to occur September 14.5, the comet's position at that time would be in about R.A.  $154^{\circ} 5$  and N.P.D.  $76^{\circ} 2$ , the distance from the earth 1.41.

Since the discovery of this comet within one day of perihelion passage in 1846 it has been observed at four returns, viz. in 1857, 1868, 1873, and 1879.

### THE IRON AND STEEL INSTITUTE

THE annual meeting of the Iron and Steel Institute took place at the Institution of Civil Engineers on April 30 and May 1 and 2. The proceedings commenced with the reading of the Council's Report and the Accountant's statement, and with the presentation of the Bessemer Medal jointly to Mr. E. B. Martin of Dowlais and Mr. E. Windsor Richards of Middlesbrough, in recognition of the part taken by them in introducing the basic process for the manufacture of steel. In returning thanks, Mr. E. Windsor Richards mentioned that his firm, that of Messrs. Bolckow, Vaughan, and Co., were now making no less than 3000 tons per week by this process from Cleveland pig-iron, such

as would have been thought, until recently, wholly unsuitable for steel-making. Sir H. Bessemer, who was present, congratulated the recipients and the steel trade generally upon the brilliant success of Messrs. Thomas and Gilchrist's invention.

The first paper read was by Mr. I. L. Bell, F.R.S., and dealt with the use of Raw Coal in the Blast Furnace. It pointed out that this question, as being more complicated than that of coke, had never been treated before the Institute, although raw coal was largely used in the United States in the form of anthracite, and in Scotland in the form of the splint coal of the Lanarkshire coal-field. It is with the latter that the paper was chiefly concerned. Taking the Brockwell seam as a good specimen of Durham coking coal, analyses were given of it first in its raw state, and secondly when converted into coke, together with the number of heat-units developed from one weight-unit of each. It appears that this number is 7437 in the case of the coal, and 7395 in the case of the coke, so that the heat developed in the two kinds of fuel is practically the same. This theoretical result was checked by experiments on a large scale made upon the North-Eastern Railway, using the same engines and the same weight of trains. The trials were continued for one week with each kind of fuel, full loads being taken to the place of shipment and the waggons returned empty to the collieries. The result in one trial in pounds consumed per train mile was 40.5 of coal and 41.6 of coke. In another experiment the difference was larger, but still it was not serious, and the theoretical deduction just given is thus fully confirmed. This equality of value between coal and coke is not, however, found to exist in the blast furnace, for the simple reason that the volatile constituents of the coal are scarcely oxidised at all, and therefore give but very little useful effect. They might, however, be utilised in another way, namely, as a means of reducing the oxide of iron to the metallic state. The gas from the coal would thus do part of the work now done by CO, and might enable a larger quantity of CO<sub>2</sub> to be evolved in the escaping gases. At present, however, this effect does not seem to be realised in practice. Analyses were given of the Lanarkshire splint coal, which show that, as a source of heat, it is inferior by about 30 per cent. to the South Durham coal. Analyses were also given of the escaping gases where this coal is used for smelting, and from this the quantity of heat evolved and appropriated was calculated, and compared with furnaces using coke. It thus appears that the raw coal occasions a much less perfect oxidation of the carbon, and in consequence a much smaller evolution of heat. On the other hand, the hydrogen contained in the coal affords a large supply of heat, but this and far more is absorbed in the expulsion of the volatile constituents, which is sufficiently proved by the very low temperature of the escaping gases, 190° C. as compared with 332° C. in the case of coke.

As regards the proportion of CO<sub>2</sub> and CO in the escaping gases, it appears that with coal it is much below the limit which Mr. Bell has fixed as the maximum compatible with reduction, viz. 1 of CO<sub>2</sub> to 2 of CO. Hence it follows that a considerable quantity of CO<sub>2</sub> must have dissolved carbon and so returned to CO. Calculating this quantity, it appears that the total carbon which reaches the hearth and gives up its heat for the fusion of iron, &c., is not very different in the two cases. Why then is there so large a disappearance of CO<sub>2</sub> in the Scotch furnace as compared with the English? Mr. Bell attributes it to the fact that the latter is 80 feet high, whilst the former, though 74 feet high, was only filled to 85 per cent. of its real capacity. The effect of the lower furnace is to diminish the time during which the ore is exposed to the reducing agency of CO, whilst still too cool for the fuel to decompose CO<sub>2</sub>. In addition it is suggested that the presence of hydrogen in the coal might cause the formation of steam, which would subsequently react on the fuel and tend to lower the percentage of CO<sub>2</sub>. On the whole it appears that when using raw coal in the blast furnace there is a waste of carbon to the extent of 3.72 units; but before recommending that the coal should be coked in order to avoid this loss, the commercial aspect of the question must be considered, and it appears that the cost of coking even where possible would in many cases exceed the saving attained. A further point, however, which needs consideration is the possibility of condensing the tar and ammonia given off by the coal and so saving the valuable products. Here we have a difficulty in the Scotch furnaces from the enormous quantity of gas which would have to be dealt with; nevertheless the results attained by Messrs. Baird in the Gartsherrie furnaces (given below) seem to show that the yield of ammonia is about the same as in the Simon-Carvès process for coking, as used

by Messrs. Pease, in which case the sulphate of ammonia and tar were worth about 3s. per ton of coal used. As theoretically five times this amount of sulphate of ammonia might be obtained from the coal, it seems probable that a large quantity of nitrogenous compounds may eventually be secured in this manner.

In the discussion on the paper, the fact of coal and coke being practically equal in heating power was confirmed by several speakers; and some interesting facts as to the anthracite blast furnaces of the United States were elicited. The advantages of calcining the limestone (which seem in most cases to be *nil*) and of mixing coke with coal in the charge were also discussed; and the important question of raw coal as an iron-smelting material may thus be said to be fairly opened.

The next two papers were taken together. The first was by Mr. R. Smith Casson on the system worked out by himself and M. Bicheroux for gas puddling and heating furnaces. This system, which has been worked with most satisfactory results in Belgium, is simpler and cheaper than that introduced by Sir William Siemens, and as regards efficiency and economy has much to recommend it. The other paper, by Mr. W. S. Sutherland, was on the most recent results in the application and utilisation of Gaseous and Liquid Fuels. It appears that Messrs. Baird and Co. are now recovering the tar and ammonia from the gases of no less than sixteen of their blast furnaces, consuming about 100 tons of coal daily. They manufacture the ammonia into sulphate and distil the tar, the actual yield per ton of coal varying from 18 lbs. to 25 lbs. of sulphate of ammonia, and from 180 lbs. to 200 lbs. of tar. The gas is found to be perfectly clean and free from moisture, and is thus better adapted than before to such purposes as raising steam, heating the blast, &c. In addition to this the paper described a new method of working the producers employed for generating gas in the Siemens or other systems of gaseous fuel, and for abstracting from the gas so obtained the tar and ammonia it comprises. It appears that a generator gas of high quality can now be got with certainty, at the same time yielding 20 lbs. of sulphate of ammonia with ten to twenty gallons of good tar per ton of coal. A net saving of from 2s. 6d. to 4s. per ton may thus be effected, and with the same result as in the case of the blast furnace, viz. that the gases are improved instead of being damaged by the removal of their valuable products. The using of such substances as tar and ammonia merely for fuel can only be considered barbarous, and it now seems probable that in a very few years it may be a thing of the past.

On Thursday the first paper read was by Mr. Walter R. Browne on Iron and Steel Permanent Way. It described the system of iron sleepers, successfully introduced by Mr. Webb of the London and North-Western Railway, and pointed out the many advantages that would result, especially to the iron trade of this country, if the use of metallic sleepers became a recognised fact. In Germany it is so already, thousands of miles being now laid with metallic sleepers; and it is to be hoped that a vigorous effort will be made to develop their use both in England and in our colonies.

The second paper, by Capt. C. Orde-Browne, R.A., dealt with the behaviour of Armour of different kinds under fire. Four kinds of armour were specified: first, wrought iron; secondly, compound armour or wrought iron with a steel face; thirdly, solid steel; fourthly, chilled cast iron. The different modes in which these yield to the impact of a shot were clearly described. Wrought iron is punched with a clean hole, the rest of the target hardly suffering any damage. As complete penetration is necessary, hardness and rigidity of metal are the essentials for a projectile, and not tenacity. Hence the extended use of Palliser's chilled shot. In compound armour the hard steel face severely tries the tenacity of the metal, so that the shot frequently breaks to pieces; at the same time the plate yields by cracking in radiating lines from the point of impact, and sometimes in concentric lines. Solid steel does not yield at the point of impact, but as the shot enters, it wedges and sets up the metal round it, the plate swelling and yielding by radiating cracks. Such cracks are much more likely to extend through the metal than is the case with compound plates. Chilled iron is broken up bodily by the direct blows of heavy shots, cracks radiating from the point of impact, which is never pierced even to a single inch of depth. Details were then given of the experiments carried out in 1882 at Essen, at Spezia, and at Ochta near St. Petersburg; in 1883, at Shoeburyness, and at Buckau on chilled cast iron; and finally experiments by Capt. Palliser and Sir Joseph Whitworth. Stress was laid on the necessity for dividing armour into two

distinct classes, soft and hard: the former signified armour which was perforated, and the latter armour which must be broken up. The difference was illustrated by a simple dropping apparatus, in which a model of a shot with a heavy weight behind it was allowed to fall either upon millboard, to represent soft iron, or upon brick, to represent hard iron. The likeness of the results to those found in practice with hard and soft armour respectively is very remarkable. It is therefore altogether a mistake, when attacking hard armour, to use the data obtained for perforation as a measure of the shot to be employed. The energy in the shot per ton of the weight of the shield is another measure which may be useful, but is not theoretically correct. To work out the problem mathematically is very difficult, and it is suggested that much might be learnt by firing steel bullets against plates of steel and chilled iron, keeping all conditions uniform except those whose relation is the object of investigation. Certainly some such experiments are needed, as are also actual trials against the hard armour, solid steel, or chilled iron, which is much used abroad; otherwise, should we be involved in a war, we might find that our calculations, based only on soft armour, would land us in disastrous failure.

The first paper on Friday was on Recent Improvements in Iron and Steel Shipbuilding, by Mr. William John of Barrow-in-Furness. This paper gave some remarkable statistics of steel-built vessels during the last few years. It appears that between 1879 and 1883 the proportion of steel vessels built and registered in the United Kingdom increased from 4·38 per cent. in 1879 to 15·7 per cent. in 1883; wooden vessels being left out of account in each case. It is evident that steel as a material for shipbuilding has passed entirely out of the experimental stage, and must be judged by the results of its working in the shipyards, and the performance of the ships already afloat. The experience of those shipbuilders who have paid most attention to steel is that it has now become a much more uniform and satisfactory material than iron, so that workmen actually complain if they are put to work upon iron, from the trouble and annoyance it involves. The only point of practical importance left is the deterioration which occasionally occurs when thick plates of steel are punched. On this further information is necessary, as also on the real cause of the failures that took place some years ago, especially those in the boilers of the *Livadia*. In some cases, metal of which the chemical analysis showed nothing abnormal, and which would bend double when the edges were carefully prepared, broke off like glass when the edges were rough, or when holes were punched in it. The paper then went on to consider the difference in cost between vessels built of iron and steel, which at the present rate appears to be practically insignificant. On the other hand, strength is decidedly in favour of steel ships, even with the present reduction of scantlings sanctioned by Lloyd's. The case was mentioned of the *Duke of Westminster*, a vessel 400 feet long, which bumped for a week at the back of the Isle of Wight on stony ground without making a drop of water. This was owing to the elasticity of the steel, and could not possibly occur with an iron ship. With regard to corrosion, Mr. Johns considered that this was a matter to be overcome by increased knowledge and care in maintenance, while there was no evidence to show that the difference in corrosion between steel and iron is sufficient to stop the progress of steel shipbuilding. Finally he observed that great attention had been paid of late to the longitudinal strains on very large ships, much greater use being made of iron decks, longitudinal stringers in the bottom, &c., so that he could no longer show, as he had in 1874, that vessels grew steadily weaker as they increased in size. In the discussion, Mr. Martell, Inspector of Lloyd's, confirmed the view that steel is infinitely superior to ordinary iron, and that there is no reason to suppose that it deteriorates faster. He mentioned a ship built in 1878 for the iron ore trade, which as yet showed no sign of deterioration. On the other hand, Mr. Jeremiah Head mentioned that, despite the progress of steel, more iron had been used in shipbuilding during the last year than ever before, and that steel plates were still much more expensive than steel rails from the necessity of hammering them after rolling. He maintained that common iron did not corrode so much as best iron or steel: the *Great Britain*, built in 1845, is still in existence, and so is a collier built in 1831. Mr. Riley confirmed the necessity of hammering, owing to the increased number of failures if this was neglected. Sir Henry Bessemer and others also took part in the discussion. This concluded the business of the meeting, the remaining papers being adjourned.